

Prepartum progesterone supplementation in swine: a strategy to facilitate piglet care and prevent early parturition

Cristina Sangoi Haas¹ Monike Quirino dos Santos^{1,2} Monique Tomazele Rovani¹
Joabel Tonelotto dos Santos² Ana Paula Gonçalves Mellagi² Fernando Pandolfo Bortolozzo²
Bernardo Garziera Gasperin^{1*} Paulo Bayard Dias Gonçalves³

¹Laboratório de Reprodução Animal, Universidade Federal de Pelotas, Faculdade de Veterinária, Campus Universitário S/Nº, 96010-900, Capão do Leão, RS, Brasil. E-mail: bbgasperin@gmail.com. *Corresponding author.

²Setor de Suínos, Departamento de Medicina Animal, Faculdade de Veterinária, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brasil.

³Programa de Pós-graduação em Medicina Veterinária, Departamento de Clínica de Grandes Animais, Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brasil.

ABSTRACT: *Gestation length in swine has a considerable amplitude and both early and delayed parturition are common. This variation increases the occurrence of unassisted farrowing and could lead to a wide-ranging age at weaning for piglets born from one batch. Supervision of sow parturition is crucial to reduce mortality of neonate piglets. To facilitate assistance, induction of farrowing using prostaglandin F2α (PGF) has been widely used in batch farrowing systems, whereby synchronization would concentrate the time of farrowing, allowing for better organization of employees. However, a viable alternative method that can be implemented to manage farrowing is to sustain high progesterone levels in the final days of gestation and, consequently, prevent early parturition. Efficient techniques to delay farrowing such as using oral progesterone supplementation have been previously described, but are only recently being considered for commercial use. The present manuscript reviews publications regarding delaying parturition and discusses the use of intravaginal devices (IVDs) containing progesterone. There is limited data addressing the effect of progesterone treatment during gestation on productive and reproductive performance. Therefore, future studies should focus on improving synchronization protocols following progesterone supplementation and evaluating piglet viability and sow fertility, before widely using progesterone supplementation to manipulate parturition.*

Key words: *farrowing induction, intravaginal device, progesterone, early parturition.*

Suplementação de progesterógenos no pré-parto em suínos: estratégia para facilitar assistência aos leitões e evitar partos precoces

RESUMO: *Como a duração da gestação de suínos pode ter ampla variação, é comum a ocorrência de partos antecipados ou gestações prolongadas. Isso aumenta as chances de partos sem assistência e leva a uma grande variação de idade dos leitões dentro do lote de produção. Portanto, a supervisão do parto é indispensável para reduzir as perdas neonatais. Para facilitar o auxílio aos leitões, a indução do parto com prostaglandina F2α (PGF) é eficaz e amplamente utilizada, sendo indicada para concentrar os partos em momentos mais adequados, preferencialmente durante o horário com maior disponibilidade de colaboradores. Uma alternativa viável é manipular o momento do parto, através da manutenção de níveis plasmáticos elevados de progesterógeno durante o final da gestação, a fim de evitar partos antecipados. Formas eficientes de evitar o parto através de suplementação oral de progesterógenos foram descritas há décadas, mas apenas recentemente tem sido cogitada a utilização comercial. A presente revisão aborda estudos disponíveis na literatura relacionados ao protelamento do parto, incluindo a utilização de dispositivos intravaginais (DIVs) impregnados com progesterógeno. São poucos os dados disponíveis relacionados ao uso de progesterógenos na gestação com índices produtivos e reprodutivos. Portanto, alguns pontos ainda devem ser melhor avaliados, especialmente com relação à determinação da sincronia dos partos após o fim da suplementação com progesterógenos, à viabilidade dos neonatos e à fertilidade subsequente das fêmeas antes da ampla adoção desta técnica.*

Palavras-chave: *indução de parto, dispositivo intravaginal, progesterógeno, parto antecipado.*

INTRODUCTION

A successful intensive swine production system is dependent on the precise management of sow fertility, as reproduction is directly related

to most productivity indexes. Therefore, hormone treatments used in different protocols are needed to facilitate estrous cycle synchronization, in addition to manipulation of the farrowing period (COWART, 2007; KRAELING & WEBEL, 2015).

To concentrate the farrowing period to a specific time window, encourage parturition supervision and provide optimal neonatal care, the current most widely-used technique is administration of prostaglandin F_{2α} (PGF). This luteolytic agent promotes corpora lutea regression and subsequently induces parturition. Several strategies involving PGF treatment have been previously described (reviewed by De RENSIS, (2012)), which clearly support that gestation in the sow is dependent on progesterone secreted from corpora lutea until the onset of parturition. Thus, this article does not aim to review farrowing induction using luteolytic agents in swine.

It is difficult to determine the beginning of gestation in swine due to the variability in the interval between estrus onset and ovulation. Furthermore, estrus detection is subjective and different personnel may consider different moments of estrus onset and, consequently, inseminate the females at different moments. Moreover, some individuals do not have minimal gestation length to allow farrowing induction during weekdays at appropriate moments (e.g., females that conceived later than their counterparts due to prolonged weaning-to-estrus interval (WEI) in sows, delayed estrus manifestation in gilts and repeated breeder females). Also, genetic selection for prolificacy in swine resulted in an increase in litter size with simultaneously higher within-litter variation in birth weight, where some piglets weighed less than 1kg (QUINIOU et al., 2002) or 1.1kg (GAGGINI et al., 2013), which is associated with increased mortality (VANDERHAEGHE et al., 2011).

Previous studies demonstrated the possibility of delaying parturition through daily oral progestagen supplementation (NELOR et al., 1975; KIRKWOOD et al., 1985). More recently, it was demonstrated that intravaginal devices (IVDs) impregnated with medroxyprogesterone acetate (MPA) can also efficiently maintain gestation (GASPERIN et al., 2011; FRELING et al., 2013). However, some aspects regarding delaying farrowing still need to be addressed, particularly those related to the interval from IVD withdrawal to farrowing, piglets' viability and sow's subsequent fertility. Pharmacokinetic of synthetic progestagen also requires further investigation, where the appropriate amount of hormone impregnated in the IVD and the maximum period of effectiveness for each dosage remain unclear.

In this review, the possibility to manipulate the farrowing period using progestagen will be addressed. Although hormonal treatments to increase gestation length have been previously described, only recently has the swine industry considered the use

of progestagen supplementation to optimize routine husbandry and piglet care, reduce birth weight within-litter variation and prevent premature farrowing. Key findings from past and recent studies are reviewed with additional support from data investigating the use of progestagen-impregnated IVDs. Furthermore, possible adverse effects that need to be assessed before widely adopting these procedures are discussed.

Physiology of gestation and parturition in swine

The average gestation length in swine is 114 days (SENGER, 2005). However, in a study using retrospective analysis of data from 94 farms, gestation length varied from 105 to 125 days (SASAKI & KOKETSU, 2007). In these studies, it is important to consider the use of farrowing induction protocols, that can alter the natural occurrence of parturition, as well as errors in data collection and registration that may explain very short (lower than 109-111 days) or long (above 120 days) gestations. Another study evaluating data from 21,824 parturitions from one farm that did not adopt farrowing induction, an average gestation length of 115.26±1.61 days was observed, varying from 110 to 120 days (MELLAGI et al., 2006). The same authors observed a negative correlation ($r=-0.19$) between the total number of piglets born and gestation length. This correlation suggested the need to periodically update the information on gestation length, as the number of total born piglets increase because of genetic selection. Apart from genetics, gestation length is also influenced by nutrition, seasonality, parity (COX, 1964; RYDHMER et al., 2008) and the presence of mummified fetuses (MELLAGI et al., 2006).

Progesterone, a hormone responsible for embryonic and fetal development (SPENCER & BAZER, 2004), is secreted by the corpora lutea during the entire gestation period, being the sow dependent on their function to maintain gestation, demonstrating that extraovarian progesterone is not sufficient (PARVIZI et al., 1976). Preparation for parturition consists in a complex cascade of endocrine signals, which is initiated by an increase in estradiol occurring approximately three weeks prior to parturition, followed by a decrease in progesterone and an increase in cortisol and relaxin one day before farrowing. Relaxin levels abruptly decrease one day before expulsion of the fetuses, whereas oxytocin concentrations peak before and during farrowing (ELLENDORFF et al., 1979). PGF is essential for parturition and its exogenous administration induces a rapid decline in progesterone levels (TAVERNE et al., 1979), whereas its blockade delays farrowing (GOONERATNE et al., 1982).

Piglets born from a short gestation (<114 days) are at risk of lower viability when compared to those born after the normal gestation period (>114 days) (VANDERHAEGHE et al., 2011). Nonetheless, it is imperative to highlight that commercial breeds and their crosses differ significantly regarding gestation length. Thus, it is impossible to determine a minimal gestation length for all sows collectively.

Premature (before 114 days of gestation) parturition may result in birth of immature piglets, reduced birth weight and low viability in the first hours of life with increased risk of mortality (RYDHMER et al., 2008; VANDERHAEGHE et al., 2011). However, early parturitions are associated with larger litters (MELLAGI et al., 2006) that have lower average birth weight. In a previous study, it was observed a decrease of 33g in the average birth weight for each additional piglet born (BEAULIEU et al., 2010). This aspect could explain, at least in part, the lower viability of these piglets, influencing the interpretation of the effect of early parturition. Furthermore, these sows are more likely to experience a decrease in milk secretion and altered colostrum composition (JACKSON et al., 1995; FOISNET et al., 2010), which may compromise piglets' future performance. Based on the aforementioned observations, techniques that reduce the incidence of premature parturition or minimize its negative effects on piglets may have beneficial effect on productivity.

Possibilities to control parturition timing to facilitate piglet care

It is well established that full-time presence of employees during farrowing is necessary for optimal neonatal care. Farrowing supervision aids to decrease neonatal death, crushing of piglets by the sow and reduces the losses owing to starvation or hypothermia. Furthermore, neonatal care ensures that piglets ingest adequate amounts of colostrum (HOLYOAKE et al., 1995), which should be at least 250g, especially for piglets weighing 1.1 to 1.2kg, according to FERRARI et al. (2014). Thus, the ability to precisely control the time of parturition facilitates overall management.

Swine producers commonly wean piglets at strategic times (in most farms; Thursdays) and consequently, most artificial insemination takes place in the beginning of the following week, which ensures that batch farrowing occurs spontaneously during week days (COWART, 2007). However, considering the variation in WEI, timing of ovulation and gestation length, a proportion of the population of sows have parturitions scheduled to occur over weekend days.

Thus, recently there is an increasing interest in technologies to manipulate and narrow the time of parturition, decreasing labor cost and improving the quality of farrowing assistance (VANDERHAEGHE et al., 2011).

To optimize farrowing assistance and ensure piglet viability during the first hours of life, pharmacological techniques were developed to restrict the time of parturition (NELLOR et al., 1975; GUTHRIE et al., 1987; DE RENSIS et al., 2012). The most studied technique to control parturition is induction with luteolytic drugs, especially PGF and its analogues, anticipating farrowing through an acute decrease in progesterone levels (KING & WATHES, 1989). Treatment with PGF is considered an effective method to narrow the time of parturition, reducing the variability in gestation length, being indicated to sows between 112 to 114 days of gestation (DE RENSIS et al., 2012). The treatment is only implemented commencing two days before the expected time of farrowing because early parturition is linked with higher risk of neonatal deaths. Thus, treatment time should consider the average gestation length in each gestation unit, taking into account variations among breeds and farms.

Several studies investigated the effect of farrowing induction on piglet viability and maternal parameters. DEVILLERS et al. (2007) reported a 20% reduction in colostrum production when parturition was induced at 113 days of gestation. However, FOISNET et al. (2011) concluded that induction at 113 days altered colostrum composition, but the volume, passive immunity and piglets performance were not significantly affected. When parturition was induced at 114 days of gestation, colostrum composition, immunoglobulin G concentration, piglets survival rate and piglets performance remained unchanged (OTTO et al., 2017). Discrepancies among studies may result from different methodologies and genetic background, suggesting the need to establish specific protocols for individual situations.

Most sows (around 80%) treated with PGF between 112 to 114 days of gestation begin farrowing up to 36h after treatment; however, there remains significant variation in the time between treatment and farrowing (DE RENSIS et al., 2012). Aiming to increase farrowing synchronization or decrease parturition length after induction, alternative protocols involving multiple PGF injections (although not practical), or PGF associated to oxytocin, have been suggested (KIRKWOOD & AHERNE, 1998; GHELLER et al., 2011).

As previously mentioned, farrowing induction is very well established in the swine

industry. However, delaying farrowing is also possible, and should be considered as a management strategy to avoid early parturitions (before the average gestation length of each unit) through maintenance of high progesterone levels during the end of gestation (FOISNET et al., 2010; VANDERHAEGHE et al., 2011; FRELING et al., 2013); although, this practice is unusual. The combination of the two approaches, avoiding early parturition and farrowing induction with progesterone and PGF, respectively, could provide a more precise control of parturition in comparison to the adoption of a single technique (GOONERATNE et al., 1979; GUTHRIE et al., 1987; KRAELING & WEBEL, 2015).

Managing the parturition time using progestagen supplementation

First studies investigating the prospect of delaying parturition in swine were conducted several decades earlier. Initially, intramuscular (i.m.) injections of progesterone (SHERWOOD et al., 1978; GOONERATNE et al., 1979) or treatment with prostaglandin synthesis inhibitors to prevent luteolysis were evaluated (GOONERATNE et al., 1982). The possibility of using oral progestagen supplementation using MPA (KIRKWOOD et al., 1985; GUTHRIE et al., 1987; WHITELEY et al., 1990) was also examined. In some studies the treatments were not 100% effective in manipulating the farrowing period (KIRKWOOD et al., 1985), demonstrating the need to establish the minimum dosage for each progestagen. The main outcomes from previous research using progestagen as a strategic tool to manage parturition are summarized in table 1.

The delay in parturition following progestagen supplementations appears mediated by inhibition of myometrial contraction, as previously inferred by WHITELEY et al. (1990) based on studies in other species. Although there are no records to support this hypothesis in swine, endogenous progesterone levels decrease during exogenous progestagen treatment, indicating the occurrence of spontaneous luteolysis (KIRKWOOD et al., 1985; WHITELEY et al., 1990). However, previous research in which sows were treated with daily progesterone (P4) i.m. injections from 112 to 114 days and were subject to farrowing induction with PGF on day 115, resulted in farrowing initiated with higher progesterone levels in P4-treated in comparison to non-treated control sows (GOONERATNE et al., 1979). These results suggested that PGF treatment reverts, at least in part, the progesterone-mediated inhibition of myometrial contractility. However, in another study,

using IVDs containing 800mg MPA, no parturitions were initiated during the 48h treatment-period, even when a luteolytic dose of PGF was administered simultaneously to IVD insertion (GASPERIN et al., 2011), demonstrating that gestation was maintained solely by exogenous progestagen.

Although pioneer studies demonstrated viable alternatives to avoid early farrowing (NELLOR et al., 1975; GOONERATNE et al., 1979), the swine industry has not adopted the technique. However, more recently, with the industry facing increasing labor costs, shortage of workers and intensive use of farrowing unit (transferring sows from gestation to farrowing unit very close to expected time of farrowing), the technique to narrow the parturition interval has gained new attention (VANDERHAEGHE et al., 2011; FRELING et al., 2013; GAGGINI et al., 2013).

Oral supplementation of the synthetic progestagen altrenogest during the last days of gestation (starting from 109-110 days; Table 1) is the most established method to maintain gestation in swine (KIRKWOOD et al., 1985; FOISNET et al., 2010; VANDERHAEGHE et al., 2011). Although efficient, altrenogest oral supplementation is not practical because it requires extensive labor and time for the daily treatment. Moreover, the treatment is costly and there are few commercial products available. Alternatively, other synthetic oral progestagens such as MPA are effective in preventing parturition (WHITELEY et al., 1990); however, its suitability for use at the commercial level has not been thoroughly investigated.

In a study using oral MPA, parturition was delayed for up to 23 days after the expected farrowing time (NELLOR et al., 1975). Evidently, prolonging gestation for an extended period induced the likelihood of piglet death. In commercial settings, increasing gestation length for one to three days would be sufficient to manage farrowing periods with greater ease. Furthermore, the use of agents known to facilitate parturition such as oxytocin or relaxin, after MPA administration, could overcome eventual alterations in expulsion of the fetuses.

There is no consensus regarding effects of progestagen supplementation during the end of gestation on parturition, piglet viability and maternal parameters. After oral altrenogest supplementation, increased parturition length and higher birth intervals were observed; however, piglet viability was not affected (KIRKWOOD et al., 1985). Nevertheless, progesterone i.m. administration from day 110 to 115 of pregnancy resulted in average gestation length of

Table 1 - Studies involving progestagen supplementation during late gestation.

Reference	Methods and main results
NELLOR et al., 1975	MPA (0.27 to 0.41 mg kg ⁻¹) was orally administered. Fetal viability and farrowing were unaffected when treatment was discontinued on the expected day of parturition. Viable piglets were obtained after cesarean section when gestations were delayed by 7 to 11 days but not after delaying >12 days. Galactogenesis occurred during MPA treatment.
SHERWOOD et al., 1978	Subcutaneous (SC) P4 injections did not influence relaxin peak and beginning of lactation. Control group: 113.8 days of gestation; 87.4% piglets born alive. SC treatment with 25mg P4 (110-113D): average gestation length of 115.7 days; 48.8% born alive. Six days P4 treatment (until day 115): average gestation length of 118.1 days; 2.5% born alive.
GOONERATNE et al., 1979	Progesterone was i.m. administered (100mg 24h ⁻¹) from days 112 to 114 of gestation with or without PGF (on day 115). It was observed a gestation length of 115.2±0.2 in the control group and 116.0±0.1 and 116.4±0.4 in P4-treated groups with or without PGF, respectively. No effects were observed on total litter size, litter weight and subsequent reproductive parameters in sows. Better farrowing synchrony was observed in P4+PGF group.
KIRKWOOD et al., 1985	Increased gestation length, farrowing duration and interval between birth was observed in alitrembolone-treated (20mg day ⁻¹ from 110 to 115 and 15mg on day 116). Five (out of 12) sows farrowed during treatment. There was no difference in litter size and birth weight.
GUTHRIE et al., 1987	Sows were orally treated with altrenogest between 109 to 112; 110 to 113 or 111 to 114 with or without PGF treatment one day after the last altrenogest supplementation. Feeding altrenogest with PGF treatment increased synchronization of farrowing (compared to altrenogest or PGF alone) and prevented early parturitions.
WHITELY et al., 1989	MPA (140 mg) fed to sows from 112 to 114 days of gestation with i.m. PGF administration on day 115 efficiently prevented early parturitions without inhibiting lactogenesis. No parturitions were observed during MPA treatment.
FOISNET et al., 2010	Daily feeding gilts with 20mg altrenogest between 109 to 112 or 113 days prolonged gestation (115.8 and 116.3 days, respectively), in comparison to control group (114.7 days). Altrenogest treatment decreased estradiol levels (in both groups) and endogenous progesterone (in gilts fed until day 113) two days before parturition. No differences were observed in number of piglets, litter weight, stillborn rate and weight gain. A trend to decreased IgG concentration in colostrum from altrenogest-treated gilts was observed.
GASPERIN et al., 2011	Gestation was maintained with IVD (800mg MPA) even when PGF was injected simultaneously to IVD insertion (on day 112). IVDs were maintained during 48h. Sows that received IVDs farrowed 82.3±3.8h whereas control sows farrowed on average 27.7±1.6h after PGF treatment. No differences were observed in total born piglets and stillborn rate.
VANDERHAEGH E et al., 2011	The occurrence of 10% of early parturitions (<114 days) was observed and sows farrowing until 112 days of gestation had more stillborn piglets. Altrenogest treatment (110 to 112 or 111 to 113) was effective to prevent early farrowings, without affecting sow's reproductive performance.
GAGGINI et al., 2013	In comparison to sows that farrowed before 114 days, altrenogest-treated sows (from day 111 to 113 of gestation) had increased gestation length (112.6±0.09 vs. 114.7±0.07 days), birth weight (1449.7±29.5 vs. 1554.7±21.2g), survival rate until 3 days (96.7 vs. 98%) and lower proportion of light piglets (13.8 vs. 8.8).
FRELING et al., 2013	IVDs containing up to 2g progesterone inserted on day 112 simultaneously to PGF treatment were ineffective in preventing parturition. IVDs impregnated with 800mg MPA were 100% effective in preventing farrowing after PGF treatment on day 112. Interval between PGF and parturition was higher for IVD-treated than for control sows. The use of IVD with 800mg MPA and PGF at IVD withdrawal did not affect parturition length, total number of piglets born, piglets viability and birth weight.

118.1 days, decreasing the number of piglets born alive (SHERWOOD et al., 1978), whereas supplementation from day 112 to 114 increased gestation length in one day (115.5±0.2 vs. 116.4±0.4 days) without affecting piglet viability (GOONERATNE et al., 1979). Other research indicated that there is no adverse effect of progestagen supplementation on colostrum volume (FOISNET et al., 2010) and on protein, immunoglobulins, lactose, sodium, calcium and potassium concentration (GOONERATNE et al., 1979). The altrenogest treatment from days 109 to 112 or 113 of pregnancy did not affect lactogenesis, litter size and birth weight (FOISNET et al., 2010).

In a retrospective study evaluating data from 60,990 farrowings in Belgium, VANDERHAEGHE et al. (2011) observed that 10% of parturitions occurred prior to 114 days of gestation. Parturitions before 112 days of gestation were linked with increased rate of stillborn piglets. The same authors demonstrated that altrenogest treatment between days 110 to 112 or 111 to 113 of gestation decreased the occurrence of early parturitions, decreasing losses related to death of premature piglets.

GAGGINI et al. (2013) showed that altrenogest supplementation from 111 to 113 days of gestation did not alter parturition length, coefficient

of variation of birth weight and number of stillborn piglets. Untreated sows that farrowed before 114 days of gestation had higher light-weight piglets rate (13.8% of piglets weighing <1.1kg) compared to altrenogest-treated sows (8.8%) and lower survival rates in comparison to sows that received altrenogest (96.7% and 98% survival rate until 3 days of life, respectively). These data are in accordance with those reported by VANDERHAEGHE et al. (2011), who observed higher mortality of piglets from early parturitions (31.2% vs. 8.9% mortality rate) in comparison to those born after normal gestation length (114-119 days). The same authors demonstrated that altrenogest treatment allowed a reduction in mortality of weak born piglets (31.2% for early parturitions vs. 15.8% for altrenogest-treated). Collectively, studies demonstrated that altrenogest treatment is an efficient technique to avoid early parturitions preventing the death of weak born piglets.

Intravaginal progestagen supplementation in sows

The possibility of using IVD supplemented with MPA to control parturition timing was investigated for the first time by GASPERIN et al. (2011). Intravaginal route allows several advantages including better control of progestagen dosage (does not depend on the amount ingested or on the parenterally administered volume), and decreased labor (only insertion and withdrawal), compared to daily oral or i.m. administrations. Initially, it was described an IVD suitable to release MPA in sows (GASPERIN et al., 2011). Then, its efficacy in controlling and synchronizing parturition and effects of the procedure on piglet viability were assessed.

The IVD efficacy was evaluated using a experimental model in which an MPA-impregnated IVD was inserted concomitantly with the PGF i.m. injection in sows (n=14) at 112 days of gestation. Thus, the only progestagen source was the IVD, because luteolysis was induced with PGF. IVDs containing 800mg MPA were 100% efficient in preventing parturition during the 48h treatment period (GASPERIN et al., 2011), even in the absence of functional corpora lutea. In this study, sows that were submitted to farrowing induction with PGF farrowed 27.7±1.6h after treatment, whereas those that received an IVD simultaneously to PGF farrowed 82.3±3.8h after PGF administration (about 34h after IVD withdrawal) (GASPERIN et al., 2011). Thus, it is possible to conclude that MPA-impregnated IVDs are efficient in maintaining gestation, representing a potential alternative to oral progestagen supplementation.

Possibility of using progesterone instead of MPA in IVDs was also investigated. However, IVDs impregnated with 0.5, 1.0, 1.5 (FRELING et al., 2013) or even 2g of progesterone (unpublished data) were not effective in preventing farrowing after PGF treatment. Lower MPA doses (100, 200 and 400mg) also failed to prevent parturition in some sows (FRELING et al., 2013). Thus, IVDs containing 800mg MPA were used to investigate the effect of progestagen supplementation on piglet viability. There was no significant difference in the proportion of viable piglets in sows that underwent spontaneous (89±1.6%), induced (90.1±1.2%) or MPA-manipulated (90.1±1.2%) parturitions (FRELING et al., 2013). Average birth weight and parturition length were also unaffected by treatment (FRELING et al., 2013). Time between the first and last piglet (3.46±0.2h) was similar to that previously reported (3.4±1.4h) after altrenogest treatment from days 110 and 113 of gestation (VANDERHAEGHE et al., 2011).

As previously stated, the scientific information regarding long term effects of progestagen supplementation during late gestation on piglet performance and sows' parameters is scarce. Possible adverse effects on fertility are particularly important when using IVDs because, apart from prolonging gestation, IVDs may induce vaginitis, increasing vaginal contamination, which can negatively affect postpartum uterine involution. Infection could disrupt milk secretion and predispose to postpartum dysgalactia syndrome (BORTOLOZZO & WENTZ, 2007). Thus, performance of suckling piglets born after progestagen-supplemented gestations should be carefully analyzed. Furthermore, possible effects on sows' subsequent reproductive parameters such as WEI, farrowing rate, total number of piglets born/litter, sow retention and culling rates should be investigated. In the study by GOONERATNE et al. (1979), prolonging gestation by one day through progesterone supplementation did not affect WEI. However, it is important to highlight that previous studies were conducted with low prolificacy sows. Therefore, studies are being conducted to evaluate the effects of progestagen supplementation during late gestation on modern sows that produce larger litters.

Despite many advantages, there are also certain limitations of using IVDs related to the use of high-hygiene standards during IVD insertion, possible losses (IVD expulsion) during treatment period and withdrawal at the right moment to avoid prolonging gestation for an increased period of time. In our experience, other limitations refer to low

synchronization of farrowing after MPA-impregnated IVD withdrawal. Farrowing occurred, on average at 48.6 ± 3.2 h after IVD withdrawal (on day 114), starting 22h after withdrawal being observed most parturitions (62.5%) between 22 and 48h (FRELING et al., 2013). Thus, despite the fact that the protocol tested by FRELING et al. (2013) was efficient in avoiding farrowing periods during weekends, the synchronization of farrowing was unsatisfactory. However, in a previous study in which sows were administered progesterone from 112 to 114 days of gestation and PGF on day 115, GOONERATNE et al. (1979) observed satisfactory synchronization, being the farrowing onset observed 36 ± 1 h after the last progesterone administration. In the same study, sows that received progesterone without PGF administration farrowed on average 48.5 ± 3 h after treatment suspension. Thus, PGF administration anticipated farrowing and improved synchronization allowing 80% of parturitions between 08:00 and 17:00. Such synchronization would require a larger number of farrowing managers available during a narrow time-period.

Independent of the route of administration, progestagen supplementation represents an alternative to better concentrate farrowing, facilitating neonatal care and increasing piglet uniformity. Another advantage would be optimal space use, considering that sows could move from gestation to farrowing units only on day 114 of gestation. Currently, without progestagen supplementation to prevent early parturitions, sows need to be transferred to farrowing unit around 109-110 days of gestation. Reducing the number of days before parturition in the farrowing unit would allow to postpone weaning, increasing piglets weight. More efficient use of farrowing facilities would also allow for better cleaning and disinfection practices.

CONCLUSION

Progestagen supplementation during late gestation is an efficient technique to control the timing of parturition. However, several aspects require further evaluation before implementing this procedure on a large scale. So far, studies demonstrated that progestagen supplementation efficiently prevents early onset of parturition allowing for farrowing synchronization, optimizing labor and facilitating farrowing supervision and neonatal care.

Progestagen-impregnated IVDs emerge as an alternative to control the timing of parturition because they are low in cost, reduce animal handling

and efficiently prevent farrowing without apparent negative effects on piglets' viability. Nonetheless, further studies investigating the maximum period of progestagen supplementation, pharmacokinetics of progestagens, subsequent reproductive parameters, possible adverse-effects and welfare aspects are necessary. Apart from those suggestions, alternatives to increase synchronization allowing for greater precision of the time between IVD withdrawal and parturition need to be established.

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